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THE LONG DRY SEASON OF 1929 IN THE FAR WEST

By EDWARD H. BOWIE

[Weather Bureau Office, San Francisco, Calif., December 24, 1929]

The normal régime of annual meteorological sequences on the west coast comprehends a season of little or no rain from late spring until early autumn, and a season of rains which on the average begins during the month of September, reaches its maximum in point of frequency in midwinter, and ends in the month of May.

The dry season is shorter and the wet season correspondingly longer on the north than on the south coast. On the coast proper the annual precipitation increases from approximately 10 inches in the vicinity of San Diego on the California coast, a short distance north of the Mexican border, to over 100 inches on the Washington coast, and farther north to nearly 300 inches on the west coast of Vancouver Island, British Columbia.[1] It is interesting to note in passing that of all parts of North America for which there are authentic records, this point, Henderson Lake, on the western coast of Vancouver Island, British Columbia, has the greatest annual precipitation.

Latitude, seemingly, is the most important control in determining the annual precipitation on the west coast. There can be no question, however, that topography is scarcely less important than latitude in determining rainfall here as elsewhere. We find, for example, local areas in southern California inclosed by high mountain ranges with the annual precipitation is less than 5 inches, and where at times one or more years may pass without the occurrence of measurable amounts of precipitation; and, again, on Vancouver Island where occurs the heaviest known rainfall of the North American Continent (approximately 300 inches), there are places where the annual precipitation is less than 20 inches, so great is the topographic effect of mountain ranges between them and the Pacific Ocean. It is interesting to observe that the latitudinal control on the west coast works oppositely to the way it does on the east coast where the greatest annual precipitation occurs in Florida and the least in Maine.

The fact that the greatest of all evaporating surfaces, the Pacific Ocean, lies adjacent to the region under consideration, might lead one to infer that the west coast would have necessarily well distributed rains in all months of the year, and that its latitudinal distribution of precipitation would be opposite to what it actually is. To reach this conclusion, however, one must ignore the fact that the evaporation goes on from an ocean surface which is materially cooler in summer than the land surface, and that consequently the air over the ocean, in passing onto the land, has its temperature materially raised, its relative humidity correspondingly reduced, and the occurrence of rain made difficult; while in the winter months, when the land surface is cooler than the ocean surface, air moving from the latter over the former has its temperature reduced, its relative humidity raised, and the condensation of its water vapor made more or less easy. It is apropos here to state the inescapable conclusion that forests can have little effect on precipitation in the Pacific Coast States, for it is during the period when forest trees are dormant that the rainy season occurs, and during the season when forest trees are transpiring moisture that there is little or no rainfall.

Furthermore, without a knowledge of the seasonal distribution of air pressure and resulting winds over the northeast Pacific Ocean and on the west coast, quite faulty ideas may well be drawn in respect to the frequency, occurrence, and travel of the important precipitation causes, namely, cyclones, of the northeast Pacific Ocean and the west coast of North America. There is no question in the mind of the writer that as the major areas of high barometric pressure with their accompanying systems of free air winds change their positions, shapes, and magnitudes, the frequency of occurrence, intensities, and paths of travel of cyclones change correspondingly. Thus, over the northeast Pacific Ocean in the summer season, i. e., the rainless season of the west coast, the barometer stands high and the system of winds is distinctly anticyclonic over the northeast Pacific Ocean. At this season of the year practically all of the cyclones of the north Pacific Ocean form over tropical waters of that ocean or pass onto it from high latitudes of the Asiatic Continent. Many of these cyclones, other than those which form off the west coast of Mexico, attempt the passage of the north Pacific Ocean in high latitudes, but few of them reach the coast of North America south of Alaska. The Bering Sea and the Bay of Alaska appear to be the graveyards of nearly all of the summer storms that attempt the crossing of the north Pacific Ocean. The area of high barometric pressure off the west coast in the summer season is an effective barrier in preventing cyclones of that season of the north Pacific Ocean from reaching our west coast. Moreover, the air coming from the ocean onto the continent, while of high humidity but low temperature, on reaching the land is heated by radiation from the surface and has its relative humidity greatly lowered, thus making precipitation impossible. During the dry season such rains as do occur are usually associated with the movement of surfaces of discontinuity or faults eastward from the coast, are local as a rule, and generally accompany thunderstorms, particularly over the mountain districts of the interior States.

[1] In 1928, Henderson Lake, Vancouver Island, British Columbia, reported 281.44 inches of precipitation.

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As the warm season wanes and the fall comes on, a change in barometric pressure distribution over the ocean as well as the continent sets in unless some unusual cause operates to prevent it. As the fall passes, the area of high barometric pressure normally centered midway between the Oregon coast and Hawaiian Islands loses in geographical magnitude, shows lower barometric readings over the area occupied, and its center retreats southward well beyond the point where it is normally found in midsummer. At the same time the barometer falls over the Gulf of Alaska, the Bering Sea, the Aleutian Islands, and thence southwestward over the ocean to Japan in which areas frequent traveling cyclones form and move eastward along the northern periphery of the anticyclone, bringing the Pacific Northwestern States under their influence and causing the dry season to end. If at any time when one of these cyclones is traveling eastward over the Pacific Ocean the more or less permanent anticyclone to the southward is well south of its normal position, the track of the cyclone to the northward will be correspondingly south of its most frequented track, provided the barometer is high over the Alaskan area and the Bering Sea. Under these conditions early fall rains are likely to occur as far south as southern California, terminating the dry season as far south as the Mexican border. The only other condition likely to terminate the dry season in southern California comes when a cyclone of tropical origin moves northwestward, its track paralleling the west coast of Mexico, and brings the southern part of California under its influence. At rather infrequent intervals such cyclones reach southern California in August or September, and when they do heavy local rains fall; but rarely do they occur north of the Tehachapi Mountains, which range lies across the State to the northward of the Los Angeles area.

As previously stated, any cause that operates to prolong the summer high pressure over the north Pacific Ocean tends to prolong the dry season in the far Western States. What the cause or causes are, other than unusual temperature distribution over continent and ocean, that prolong the dry season type of pressure distribution, it is difficult to visualize; but that it or they operated to prolong the dry season through the fall months and into December of 1929, is clearly shown by the records of precipitation during the period to which this article refers. Moreover, the cause or causes must have been operative over a large geographical area to have produced what is generally regarded as the longest dry season of record over an area as large as that of the far West.

The following table gives comparative precipitation data at stations in the far Western States for July to November inclusive. The first column in this table gives the seasonal catch of precipitation during July to November, 1929, inclusive; the second column, the normal or average precipitation July to November inclusive; the third column the least amount of precipitation in these months prior to 1929; and the fourth the year when it was recorded. A fifth column gives the year when the record began.

Table showing comparative precipitation for stations in the far Western States for the period July to November, inclusive

Station	Seasonal, July to November, 1929, inches	Normal, July to November, inches	Least seasonal, July to November		Record began, year
			Inches	Year	
Seattle, Wash	3.58	10.97	3.56	1895	1891
Tacoma, Wash	2.47	13.02	5.63	1917	1878
Spokane, Wash	0.85	5.47	1.37	1917	1881
Tatoosh Island, Wash	15.46	27.82	15.13	1923	1884
North Head, Wash	4.83	18.19	8.96	1917	1878
Portland, Oreg	2.56	12.45	4.11	1890	1871
Walla Walla, Wash	1.73	5.32	1.37	1890	1886
Lewiston, Idaho	1.22	4.81	1.06	1890	1878
Boise, Idaho	0.63	3.39	0.06	1868	1868
Pocatello, Idaho	3.56	4.56	2.00	1902	1899
Baker, Oreg	0.82	3.77	1.23	1892	1889
Winnemucca, Nev	0.14	2.12	0.12	1880	1877
Reno, Nev	0.69	1.73	0.38	1915	1888
Eureka, Calif	0.22	8.81	1.00	1880	1878
Red Bluff, Calif	0.10	5.18	0.22	1880	1877
Sacramento, Calif	0.15	3.18	T.	1850	1850
San Francisco, Calif	0.01	3.95	0.33	1890	1849
San Jose, Calif	T.	2.53	0.10	1890	1874
Fresno, Calif	0.01	1.73	0.19	1893	1881
Los Angeles, Calif	0.32	2.08	0.06	1891	1877
San Diego, Calif	0.26	1.45	0.05	1894	1850

The situations arising from the delayed ending of the dry season of 1929 were distressing in many sections of the far West, but while serious they were not unduly alarming. Nevertheless, water became scarce in many sections for domestic purposes, for stock, for irrigation, and for hydroelectric power and lighting, except where supplies for long periods had been impounded. There was delay in the seeding and planting of fall crops and there was no pasturage in California for stock and hence feeding became general in November. The public mind was greatly concerned lest the usual winter rains might not occur, and no doubt the lengthened dry season to a considerable degree affected plans for outlays of credit and budgeting of funds for many purposes. This state of mind changed as soon as the rainy season started in the second week of December.

An examination of the weather charts for the fall months of 1929 shows a number of anomalies, but what they might be attributed to can not be stated with precision. Apparently observations from a much larger area than that now covered are necessary to determine the physical processes that underlie such radical departures from normal or average conditions. Moreover, much effort and skill will be required to interpret such data and state the true explanations of abnormalities of this order. It is quite certain that their first causes will not be made known by chance or through revelation. The most obvious of the anomalies were:

1. The continuation through September and October of high or relatively high barometric pressure over the north Pacific Ocean in latitudes where ordinarily found only in the summer season, and at the same time low barometric pressure over the Bering Sea, the north portion of the Gulf of Alaska, and along and south of the Aleutian Islands.

2. In November extraordinarily high barometric pressure was general along and off the western coast, over the Plateau region and western Canada.

3. During the early fall months the upper air winds reported by pilot balloon stations showed normal summer conditions, i. e., variable but mostly southwest at high altitudes over the far Western States.

4. In November the winds over the far Western States up to high altitudes were prevailingly from the north [1] as shown by pilot-balloon runs, whereas normally they would be changeable between southwest and northwest.

5. Over the ocean in November the barometer stood high over and off our western coast to a considerable distance, but over midocean and the Bering Sea it stood low with numerous cyclones forming and moving north or northeastward to the Bering Sea and the Bay of Alaska. No one of these of importance reached the coast of North America south of Vancouver Island.

6. It would appear that the September and October cyclones of the north Pacific Ocean were unable to penetrate the high barometric pressure and its system of winds; instead they moved along the northern periphery of the high pressure area in high latitudes.

7. The high barometric pressure along and off our western coast during November was an effective barrier to the eastward advance of many cyclones that made their appearance over midocean and moved to the Bering Sea where they disappeared beyond our field of observations.

8. The northerly winds prevailing up to high altitudes over the far Western States would account for the scarcity of precipitation in that region during November. This occurrence was associated with the high barometric pressure referred to in 2, and it, no doubt, occurred in response to temperature abnormalities over a large area. It will be recalled that with the trial forecast of the seasonal rainfall for southern California for the winter of 1929–30, issued by the Scripps Institution of Oceanography, the statement was made that the water temperatures off La Jolla, Calif., during the summer of 1929, were the highest recorded since observations began there. If high water temperatures prevailed over a considerable area of the ocean off the western coast of Mexico through the fall of 1929, and that seems altogether possible, we should have an explanation of the prevalent north winds over the far Western States during November.

9. Reference is made in 5 to the occurrence of cyclones over midocean and to their passing north and northeastward. It seems likely that west of the current of northerly winds prevailing in that month along our western coast, there must have been a countercurrent, a south wind, along which these midocean cyclones traveled to the Bering Sea. It is also possible that this south current accounted for the high temperatures in the interior of Alaska in that month.

10. The pressure rose decidedly in the early part of December over the Bering Sea and the western parts of Alaska, forming an area of high barometric pressure that extended thence eastward over Canada, and at the same time pressure gradually fell off our west coast and over that part of the ocean thence westward to and beyond the Hawaiian Islands. At the same time the northerly winds of the Western States gave way and became southerly and westerly. With this readjustment of the pressure situation over the northeast Pacific Ocean, the Bering Sea and the adjacent areas of the North American Continent, cyclones formed over the middle latitudes of the north Pacific Ocean and traveled toward the west coast, so that during the second week of December the dry season had ended generally in the far Western States except in southern California.[2]

The several distributions of barometric pressure with their associated wind systems, to be referred, of course, to the temperature distribution over large areas, are unquestionably what brought about the prolonged dry season in the far Western States in 1929.

It will be noted in paragraph 1 that the pressure distribution during the fall up to and including October of 1929 was such as to prevent the approach of cyclones to our coast south of latitude 50°; and that in numbered paragraph 2 reference is made to high barometric pressure and northerly winds along and off our western coast, which the cyclones over the ocean to the west could not penetrate. These cyclones were carried northward to the Bering Sea by a countercurrent, a south current, presumably of great width and considerable depth over midocean. It will be noted further that when the pressure rose in high latitudes, notably the Bering Sea and western Alaska, and decreased over the northeast Pacific Ocean (see par. 10) the dry-season soon came to an end, i. e., during the second week of December, except in Southern California.

WEATHER AND COTTON YIELD IN TEXAS, 1899–1929, INCLUSIVE

551.5 : 633.51 (764)

By LAWRENCE H. DAINGERFIELD

[Weather Bureau Office, Houston, Tex.]

The tropical origin of cotton is easily demonstrated by its tolerance of heat and marked intolerance of cold. While it generally is safe to sow wheat when the average daily air temperature reaches 37° to 38° and oats at 42° to 44°, and plant corn at 55°, cottonseed should not go in the ground until the mean warmth reaches 62°, according to trustworthy authorities. Thus the planting period in Texas during a normal year may range from late February in the lower Rio Grande Valley until the middle of May in the northwestern cotton limits of the State. As a matter of fact there are wide variations from the normal planting dates due to early or backward seasons in consequence of favorable or unfavorable temperatures, and the presence or absence of moisture.

Roughly speaking, a month to six weeks may elapse in a normal season after the last killing frost of spring before the soil reaches the best temperature for proper germination; examination of frost tables will show this to be a fact. The warming-up process in spring and, conversely, the chilling in autumn are more rapid in the interior of the State than near the coast.

For the best growth of the plant, sustained high temperatures are favorable, both night and day, with a summer mean of not less than 77° F. The older varieties of cotton required a growing season of not less than 200 days for best results. New short-season or precocious varieties, with much less vegetable growth have shortened the season considerably, especially in the northwestern and western sections of the State. Cotton now normally begins to mature in from 100 to 135 days after planting, with a maturing period ranging from possibly only two weeks to as much as two months.

The first killing frost in autumn does not hold as much dread as formerly due to the introduction of early varieties, tendency to earlier planting, and for other reasons. Excessive rain during time of harvest, thus delaying pick-

[1] In the Pacific States north winds are dry and hot in summer and dry and cold in winter.—*E. H. B.*

[2] The dry season continued in southern California through December.